Metallic Zinc Powder as a Paint Pigment

New Jersey zinc

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Metallic Zinc Powder as a Paint Pigment

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Metallic Zinc Powder is also known in the trade as Zinc Dust. The material covered by this bulletin is not a by-product made in the smelting of zinc ores, but is distilled in furnaces especially designed and operated for the sole production of metallic zinc powder.

SUMMARY

ZINC DUST was recommended and used in Europe as a paint pigment at least as early as 1840. Reports by recent visitors in the industrial districts of France, Belgium and Western Germany state that zinc dust paints are now used almost exclusively for plant painting. Zinc dust is also being used extensively in marine paints, both here and abroad.

Practical tests, involving the application, to date, of about 2000 gallons of paint, as well as the usual panel tests, have been made under the supervision of this laboratory as follows:

1. On steel and galvanized structures, both as the primer for the ordinary finish paints and as a final coat. These include sheet iron buildings, transformers, transmission towers, trestle work, tanks, etc.

2. On sections of the interior of a large industrial water tank.

3. For repainting buildings on which the old paint was badly cracked and which required special treatment unless the old paint was removed by burning.

4. As a primer on sappy redwood clapboards of a new house.

5. For miscellaneous purposes, such as on screens, canvas roofs, interior of a galvanized light exposure tank for accelerated weathering equipment, etc.

6. Zinc dust has also been used as the pigment in lacquer enamels and as a tinting pigment stirred into outside white house paints.

These tests, plus the reports of tests in other laboratories, lead to the following conclusions:

1. As a rust inhibitive metal primer it is at least equal to any other high grade commercial primer. Ordinary finish coat paints adhere to it and give the maximum of service.

2. It also makes a grey finish paint with a very high hiding power that completely covers any surface in one coat. It holds its color and does not crack upon exposure.

3. Its peculiar property is that although the surface is hard enough to shed dirt readily, the film maintains its distensibility over long periods of time. This is perhaps due to an anti-oxident effect of the metallic zinc.

This property makes zinc dust especially useful in repainting over old paint that is badly cracked and must be firmly held in place.

4. The same properties make it an excellent primer for refractory woods, galvanized iron, sheet zinc and other surfaces that usually cause painting troubles due to poor adherence.

5. The optimum amount of zinc oxide to use with zinc dust for ordinary painting purposes is 10% to 25% by weight of the pigment. For priming iron and steel, about 20% zinc oxide is recommended.

6. Ordinary Raw and Boiled Linseed Oil Vehicles give excellent results.

7. It is easy to prepare. Zinc dust needs only be stirred in dry with oil or with oil and zinc oxide paste. Zinc dust incorporates equally well with lacquer enamel vehicles.

8. With ordinary oil vehicles, zinc dust does not "cake" hard in the bottom of the container. Adding zinc oxide keeps it from settling.

9. Hydrogen gas is slowly generated by the reaction between the finely divided metallic zinc in the zinc dust and any free acid in the vehicle. Hence, only oil of low acid number can be used as the vehicle, if the material is to be stored in sealed containers, and acid driers, particularly, must not be used. Zinc dust-zinc oxide pastes made with a minimum of low acid raw linseed oil (about 6-7%) are practically free from this difficulty.

10. Pastes and paints made with zinc dust do not "skin" readily and can be very conveniently stored in containers with air vents, so that for practical purposes the acidity of the vehicle used is not a vital matter.

11. No gas formation has been detected when zinc dust is mixed with typical lacquer enamel vehicles.

12. This paint costs considerably less than red lead paint.

Metallic Zinc Powder as a Paint Pigment

By H. A. Nelson and W. A. McKim

I

Purpose of This Bulletin

ALTHOUGH the tests being conducted by this laboratory on the use of zinc dust as a paint pigment are not complete and final, the results so far obtained are so encouraging that they are worth publishing. Other tests in the United States, as well as the history of the use of zinc dust paints abroad, seem to check the favorable findings here reported. However, it is only by varied experience in many different uses that the real place of any pigment or paint is determined, and it is the primary purpose of this bulletin to present practical information and formulas so that known and tried paints may be made up by those interested and any further experiments most wisely inaugurated.

II

History of the Use of Zinc Dust as a Paint Pigment

According to evidence in the literature and reports of persons who have lately visited there, zinc dust has been and is being used in considerable quantities in Continental Europe as a paint pigment.

The earliest known references to the use of zinc dust paint are by R. Mallet[1] in 1840 and by Schwarz[2] in 1864, followed by Liecke[3] in 1867. Lodin[4] in describing the manufacture of zinc dust, mentions paint as the first outlet for the material, stating that "In former times zinc dust served only for the preparation of a grey paint destined to protect iron against oxidation . . ."

Zerr and Rubencamp[5], German authors, in describing zinc dust paint, refer to its great covering power and its successful use as a rust inhibitor. Its use on machinery, sheet iron, roofs, etc., is recommended.

[1] R. Mallet, British Assn. for Advancement of Science, 1840, p. 241.
[2] Schwarz-Wagners Jahresbericht 1864, seite 606.
[3] Liecke-Wagners Jahresbericht 1867, seite 45.
[4] A. Lodin, Metallurgie du Zinc, 1905, p. 605.
[5] Zerr and Rubencamp, Handbuch der Farbenfabrikation, seite 181, 1908.

Coming to more recent references, according to Jennings[6], zinc dust paint has an excellent reputation on the continent, where it is known as "zinc grey."

Coffignier[7], the well-known French authority on paints, oils and varnishes, gives the following formula as yielding a paint unexcelled for rust inhibitive purposes:

Zinc Dust	1.000 Kilo
Linseed Oil	.300 Kilo
Turpentine	.025 Kilo
Manganese Resinate	.010 Kilo

The problem of marine painting opened another field for zinc dust paint in Europe. Billaz[8], in referring to the properties of zinc dust, mentions its non-reactivity with dry oxygen. With moist air a film of basic hydrocarbonate forms on zinc dust, while with sea water an oxychloride is formed which is very protective for steel, hence the adaptability of zinc dust for paints in marine work. The Metallbörse[9] states that the French Navy uses the following mix as paint for ship plates:

Pigment 84%	Vehicle 16%
90% Zinc Dust	41% Linseed Oil
10% Zinc Oxide	35% Turpentine
	24% Drier

Personal investigation (*From data recently obtained by Dr. E. D. Martin while studying the Zinc Industry in Continental Europe*) has also proven that large industrial plants in France, Belgium and Western Germany do use zinc dust paints almost exclusively. For example, M. Gruner, Directeur of the Levallois-Perret plant of the Societe Anonyme des Mines et Fonderies de Zinc de la Vieille-Montagne, located at Rue Collange, Paris, has stated that in Europe zinc dust paint is experiencing "an increased and general use for preserving metal surfaces in industrial plants." The entire plant located at the above address is painted grey with a paint composed of two parts by weight of zinc dust, one part zinc oxide mixed in linseed oil, turpentine and drier. The Valentin-Cocq (Belgium) plant of the same company is likewise painted with this paint. On going up the Sarre Valley, which extends into Germany, one finds the immense iron and steel mills, such as the Dillengen Hüttewerke, painted with zinc dust paint. In fact, it is the exception to find industrial plants in this section of Europe not painted with a zinc dust paint.

[6] Arthur Seymour Jennings, 1914, Commercial Paints and Painting, p. 21.
[7] Coffignier, Ch., Rust Protective Paints, Le Moniteur de la Peinture, No. 58, pp. 18–19, No. 59, pp. 41–2, 1922.
[8] A. Billaz, Notes on Zinc Dust. L'Industrie Chimique, Vol. 9, No. 99, pp. 152–157, April, 1922.
[9] Metallbörse, Vol. 11, No. 27, p. 1311, July 2, 1921.

Apparently the earliest reference to the use of zinc dust in anti-corrosive paint in America is that by Henry Williams[10] in his description of the development of the Norfolk ship-bottom paint, now known as Navy Department formula No. 14.

The next American reference to the superiority of zinc dust as a metal protective paint was made in 1913 by D. Davidson[11]. Test plates exposed outdoors two years and under water one year showed zinc dust was in the best condition of any at the end of the test.

As long ago as 1916 Gardner[12] referred to the use of zinc dust in paints for subaqueous exposure and recommended the wider use of this pigment for under-water paints. He[13] again refers to zinc dust in 1919, describing excellent results obtained after two-year outdoor exposure on metal panels.

In regard to aging properties, Gardner[14] states that a paint composed of 80% (weight) zinc dust and 20% raw linseed oil settled after standing in containers for nine months. No caking was observed. This paint, after 52 months' exposure on metal panels, was described[15] as being in excellent condition, with only a slight amount of rust formed at the edges of the panel. This same paint when used as a primer with a finish coat of aluminum paint gave excellent results after 52 months' exposure.

Following an entirely different line of endeavor Gardner[16] found that a paint made of equal parts by weight of zinc dust and zinc oxide in a vehicle consisting of boiled linseed, turps and drier, when used as a primer on redwood and red cedar, effectively prevented resins from exuding from the wood and staining subsequent coats of white paint. This same paint when used as a primer on species of wood considered refractory to paint, such as cypress, reduced the tendency of the finish paint towards checking and cracking.

Very recent reports by Figg[17] before the Oil and Colour Chemists' Association, of tests on water-line paints on the piers at Woolwich (England), are to the effect that after 58 weeks the results "..... indicate that for the conditions given, the best protection is afforded to steel work by two coats of a special paint consisting of zinc oxide and zinc dust in raw linseed oil."

[10] Henry Williams, Naval Constructor, U. S. Navy, *Engineering News*, Vol. 66, No. 5, p. 137, August, 1911.
[11] D. Davidson, Metallic Pigments, Jour. Ind. Eng. Chem., Vol. 5, p. 83, Jan., 1913.
[12] H. A. Gardner, Circular No. 49, P. M. A., May, 1916.
[13] H. A. Gardner, Circular No. 61, P. M. A., April, 1919.
[14] H. A. Gardner, Circular No. 130, P. M. A., July, 1920.
[15] H. A. Gardner, Circular No. 231, P. M. A., April, 1925.
[16] H. A. Gardner, Circular No. 222, P. M. A., December, 1924.
[17] *Chem. Trade Journal and Chem. Engineer*, November 20, 1925, p. 594.

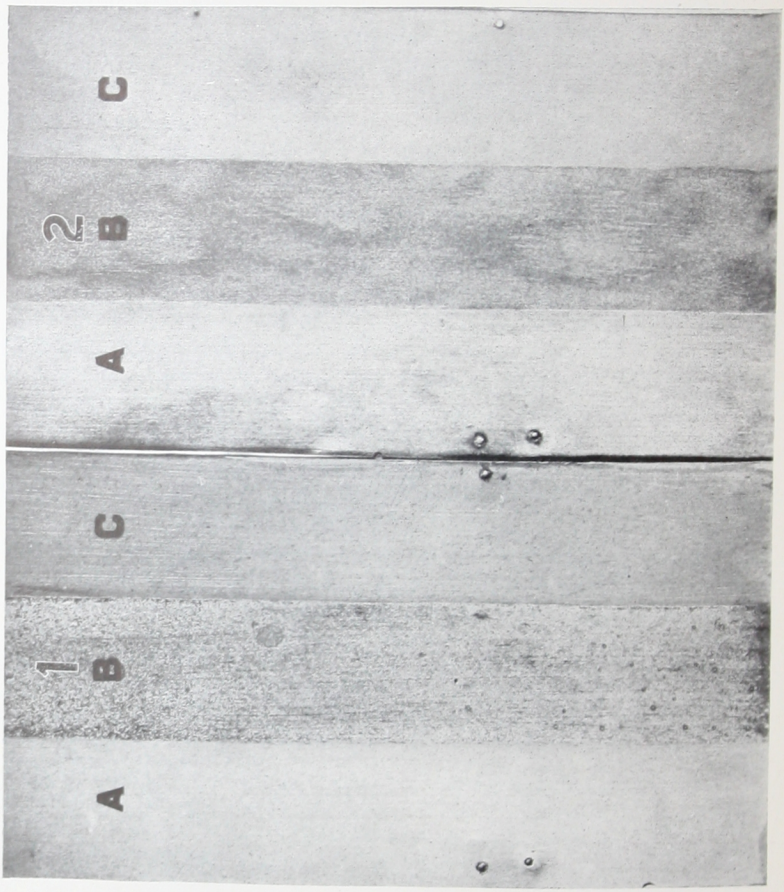

FIGURE I

Two representative panels of a test series after 3¼ years' exposure at 45° angle facing ~~north~~ south. (O. H. Steel panels.)

"*A*"—Two coats of the priming paints alone.

"*B*"—One coat of the priming paints.

"*C*"—One coat of the priming paints plus two coats of a grey industrial finish coat paint.

Panel No. 1, Red Lead		Panel No. 2, Zinc Dust	
77% Pigment	23% Vehicle	75% Pigment	25% Vehicle
100% Red Lead	94% Raw Linseed Oil	75% Zinc Dust	85% Raw Linseed Oil
	3% Turps	25% XX Zinc Oxide	10% Turps
	3% Oil Drier		5% Oil Drier

III

Scope of Tests

The experimental work conducted by this Laboratory on zinc dust as a paint pigment includes outdoor exposures on standard test panels of steel and wood, industrial structures and houses, as well as accelerated weathering tests. In this connection, to date, over two thousand gallons of zinc dust paint have been applied both by brush and spray methods at Palmerton without encountering any difficulties in making the change from other paints.

Some typical results of these tests are illustrated by the photographs that are shown herewith.

Figure I illustrates the present condition of two of a series of open hearth steel panels (12″ x 24″) that have been exposed for 3¼ years at a 45° angle, facing south, on a hillside overlooking an industrial plant. Panel No. 2 is painted with a 75% (by weight) zinc dust-25% zinc oxide combination paint, as described in the figure, and Panel No. 1 with 100% red lead. Panel No. 2 is entirely on a par with Panel No. 1. Moreover, the zinc dust paint has the further advantage, proven by the color and general condition of section A (two coats of zinc dust-zinc oxide paint), that it is entirely practical as a finish coat, as well as for priming purposes.

Figure II illustrates another set of tests on ordinary Bessemer steel panels. Bessemer steel (copper content below .05%) panels are generally used in such exposure tests because of their tendency to corrode excessively by pitting, thus presenting the worst conditions for a priming paint. For example, compare Figure I (a good grade O. H. Steel), after 3¼ years' exposure with Figures II and III (Bessemer Steel), after 1½ to 2 years' exposure. Copper bearing steels show the same advantages of freedom from a pitting type of corrosion, and this is worthy of attention, in considering plant maintenance by painting, no matter what paint is used. In Figure II the general superiority of Panel No. 2 (75% zinc dust-25% oxide) is quite evident.

Figure III illustrates another set of tests on Bessemer steel exposed 25 months under the same conditions. In this case, however, the paint on Panel No. 2 is 100% zinc dust. The only corrosion on this panel is at the extreme lower end of section "B" (1 coat zinc dust paint), whereas the characteristic pitting corrosion of Bessemer steel is more or less evident on the other two panels.

Zinc dust-zinc oxide paints have been successfully applied by ordinary spray methods to dozens of plant structures, such as illustrated in Figure IV. This photograph was taken one year after application of the paint,

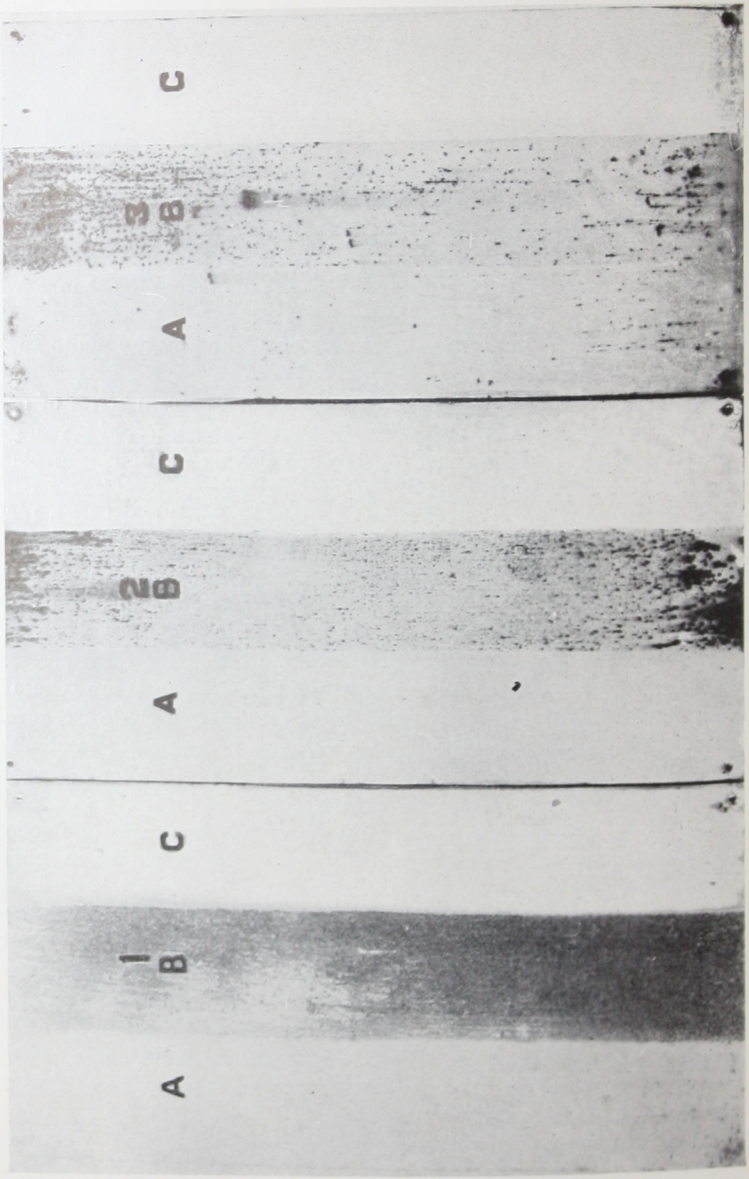

FIGURE II

FIGURE II

Three representative panels of a test series after 1½ years' exposure at 45° angle facing south. (Bessemer steel panels.)

"*A*"—Two coats of the priming paints alone.

"*B*"—One coat of the priming paints.

"*C*"—One coat of the priming paints plus two coats of a grey industrial finish coat paint.

Panel No. 1, Blue Lead		Panel No. 2, Zinc Dust	
66% Pigment	34% Vehicle.	76% Pigment	24% Vehicle
100% Blue Lead	90% Raw Oil	75% Zinc Dust	97% Boiled Linseed Oil
	5% Thinner	25% Zinc Oxide	3% Oil Drier
	5% Oil Drier		

Panel No. 3, Red Lead

78% Pigment	22% Vehicle
100% Red Lead	90% Raw Oil
	8% Thinner
	2% Oil Drier

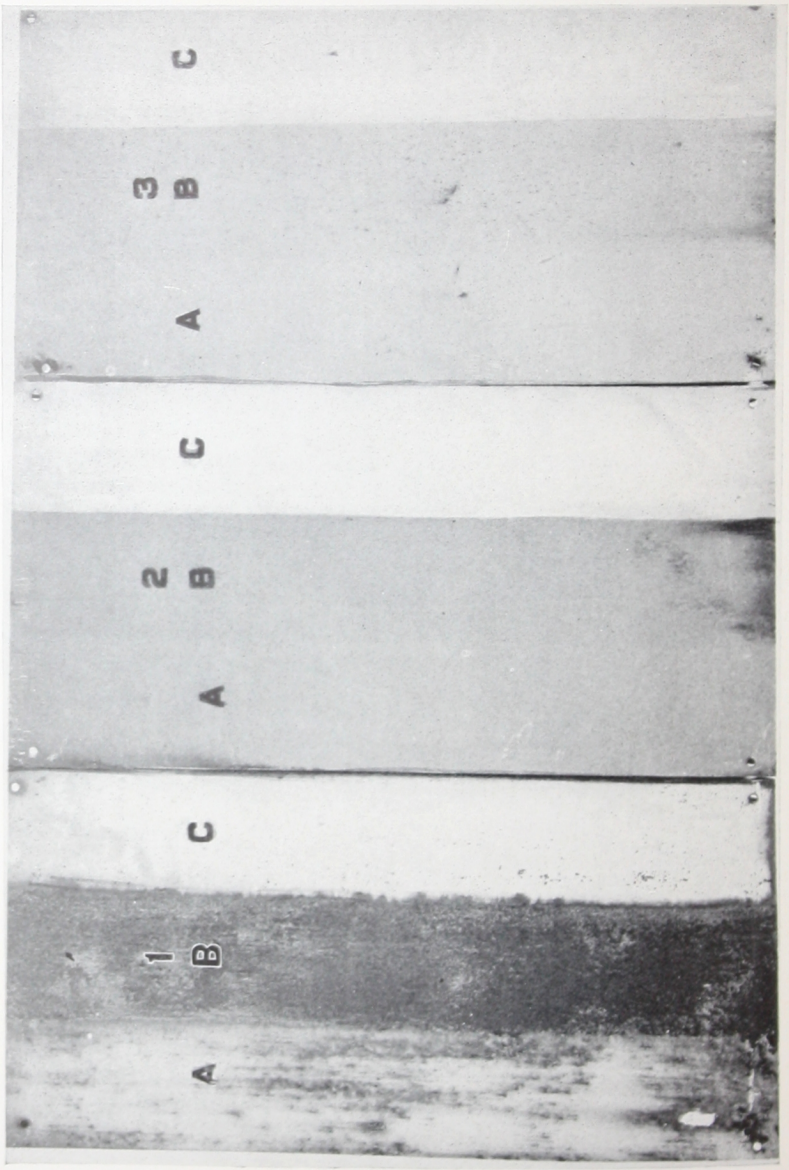

FIGURE III

FIGURE III

Three representative panels of a test series after 25 months' exposure, at 45° angle facing south. (Bessemer Steel panels.)

"*A*"—Two coats of the priming paints alone.

"*B*"—One coat of the priming paints alone.

"*C*"—One coat of the priming paints plus two coats of a grey industrial finish coat paint.

Panel No. 1, Aluminum Powder		Panel No. 2, Zinc Dust	
22% Pigment	78% Vehicle	82% Pigment	18% Vehicle
100% Aluminum Powder	97% Boiled Oil	100% Zinc Dust	97% Boiled Oil
	3% Oil Drier		3% Oil Drier

Panel No. 3, Red Lead	
78% Pigment	22% Vehicle
100% Red Lead	90% Raw Linseed Oil
	8% Thinner
	2% Oil Drier

only one coat having been applied. The paint presents a clean and uniform appearance, as shown by Figure V, in spite of the fact that this exposure is in a very dusty section of an industrial plant.

Figure VI illustrates the use of the spray gun in the application of a 75% zinc dust–25% zinc oxide paint on a highway bridge. The handling of zinc dust paints for spraying will be discussed in more detail later.

A year and a half ago, when the interior of an industrial water tank was being painted, test strips of linseed oil paints made up with 75% zinc

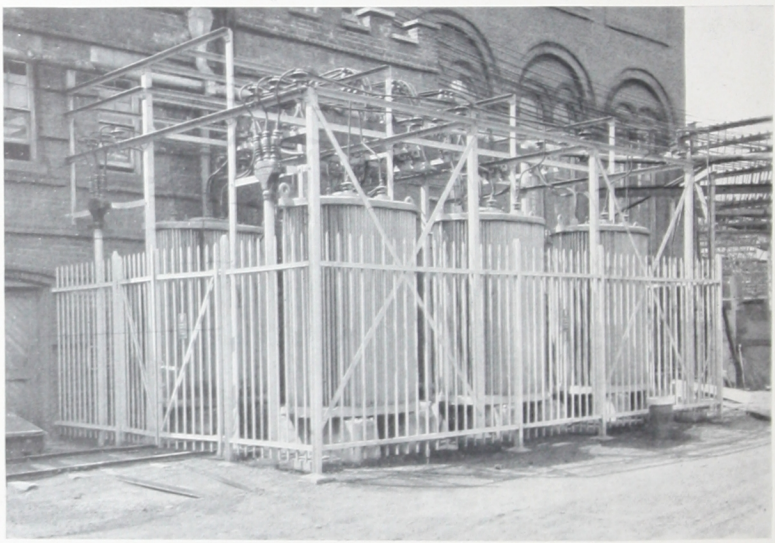

FIGURE IV

Typical industrial job sprayed with zinc dust-zinc oxide paint. (See Figure V.) (Appearance is similar to that of galvanized metal.)

dust–25% zinc oxide were applied in two coats. Recently, the water was drained and the strips found to be in perfect condition, as shown by Figure VII. The superiority of the zinc dust paint over the paint which has been regularly used in painting such tanks was evidenced by (1) a cleaner surface and (2) an absence of blisters, both of which are evident from the photograph. The paint previously used on the interiors of these tanks was an iron oxide-zinc oxide paint, which had given about five years' service previous to this repainting.

Probably the most striking illustration of the exceptional adhering properties of zinc dust paints is shown by Figure VIII, which is a photograph of a section of the interior of the galvanized cover to the accelerated weathering equipment in this laboratory. The question of getting paint to adhere to the galvanized metal used in these tanks has always been a troublesome one. In this case, the new galvanized iron cover was painted directly with two coats of 75% zinc dust–25% zinc oxide (made up with boiled linseed oil) without any previous roughening or treatment of the

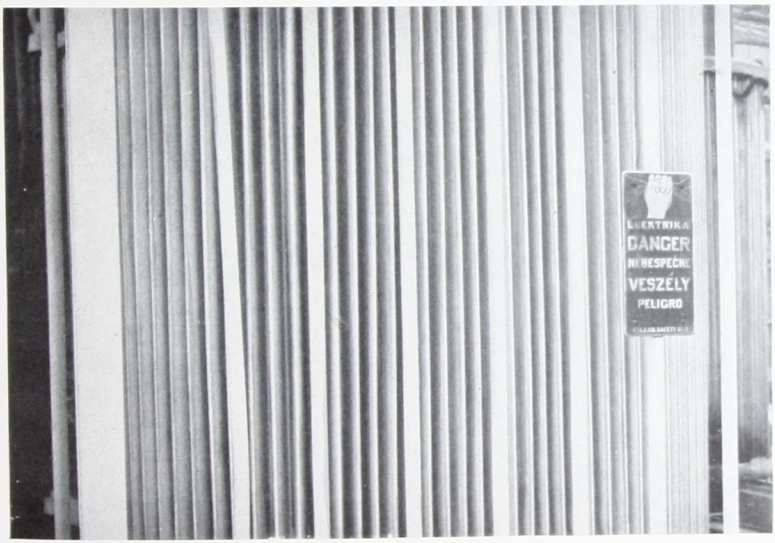

FIGURE V

Close-up photograph of transformers shown in Figure IV, showing the clean appearance of the paint after one year of exposure in a dusty section of an industrial plant.

surface. Although the exposure to ultra-violet light at 100% relative humidity and a temperature of 60°C. with periodic cooling has gone on uninterruptedly for over four months, the adherence to the galvanized surface remains perfect. There is absolutely no flaking away of the paint film, when scraped with a knife. The severity of the exposure is evident from the discoloration that has occurred where accumulated moisture has dried on the surface.

Large areas of sheet zinc have also been painted with the same paint for over a year without showing any evidence of the objectionable looseness of the priming coat that is so commonly found on surfaces of this kind unless weathered or specially prepared for painting. It should be noted that we still recommend, as an added margin for safety, that sheet zinc and galvanized iron be weathered, washed with benzol, or treated with copper acetate solution and rinsed with clean water to remove soluble salts remaining on the surface before any paint is applied.

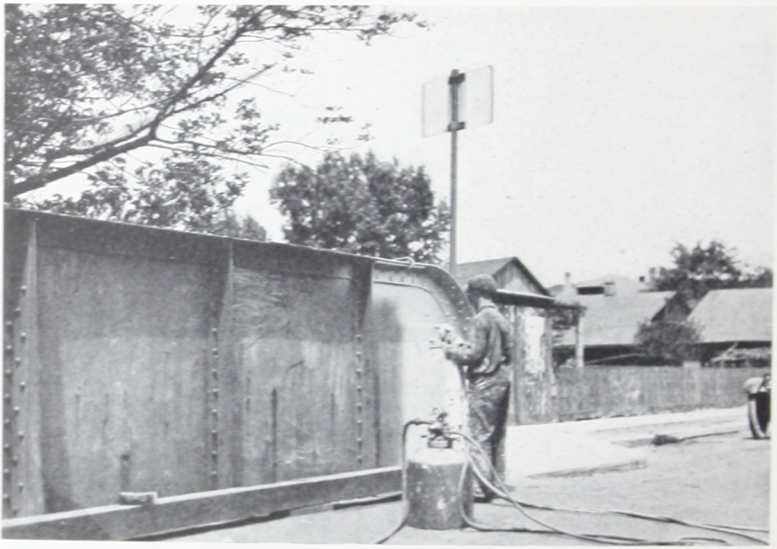

FIGURE VI

Spraying 75% zinc dust–25% zinc oxide paint on a highway bridge.

IV

SOME PROPERTIES OF ZINC DUST PAINT

Plastic Film

The quality of a paint film containing zinc dust that immediately appeals to any one accustomed to examining paint films that have been weathered is its retention of distensible properties. This is graphically illustrated by the photomicrographs (Figure IX (a) and (b)) of a 75% zinc dust–25% zinc oxide paint film after one year's service on the exposed south side of a wooden structure. The original cut (a) is typical of any cut

in a plastic material, where no shattering or tearing of the edges is revealed even under the microscope. (b) Further shows how the paint could be pressed back into place and the cut practically healed by molding the plastic paint. Obviously, this property of the zinc dust paint film makes it especially useful on repaint jobs, for example, where the condition of the old paint may be such that a brittle film must be avoided. Also, it undoubtedly is this property that causes zinc dust paints to adhere so well to galvanized iron, sheet zinc and wood surfaces, on which it is difficult to obtain effective priming.

This property is further graphically demonstrated by stress-strain measurements, such as shown in Figure X. These tests were run by the

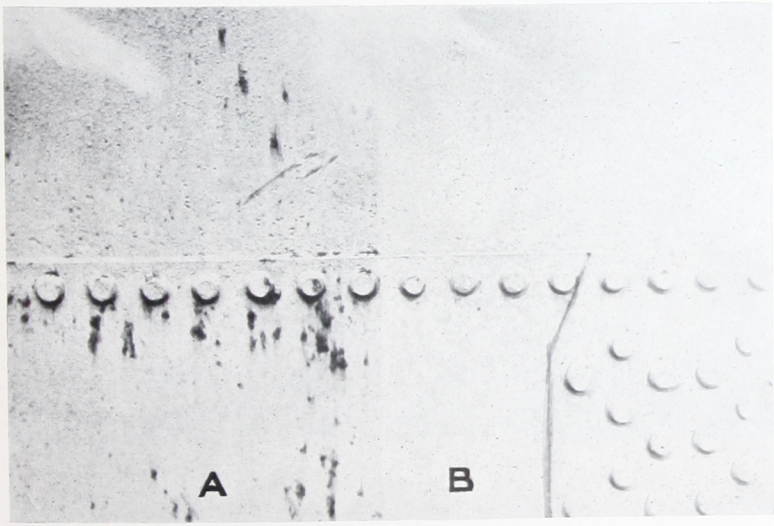

FIGURE VII

Interior of industrial water tank after 18 months' service. Photograph taken about 10 feet below water level. Note clean appearance and freedom from blisters on "B."

"*A*"—Two coats of iron oxide-zinc oxide paint that has been successfully used for several years.

"*B*"—Two coats.

76% Pigment	24% Vehicle
75% Zinc Dust	92% Raw Oil
25% XX Zinc Oxide	4% Thinner
	4% Oil Drier

methods described in a Research Bulletin on "Some Physical Properties of Paint and Varnish Films."[18] The outstanding things indicated by such tests are (1) the relatively slight effect on the physical properties of the film of changes in the relative humidity of the surrounding atmosphere, (2) the retention of distensive properties even after a relatively severe exposure to ultra-violet light and (3) the superior general toughness of the film, as indicated by the longer stress-strain curves.

FIGURE VIII

Photograph of a section of the galvanized iron cover to an accelerated weathering equipment. This cover, painted without any weathering or copper sulfate treatment with 75% zinc dust–25% zinc oxide paint, has been exposed to the extremes of the light, heat and moisture conditions in this tank for over four months. Adherence is still perfect. Paint film can not be scraped clean from the metal.

The attitude generally taken by those writing about the use of zinc dust as a paint pigment has been that it owes (or should owe) its good properties as a primer for iron and steel to the fact that zinc is electropositive to iron and, hence, that zinc dust offers some of the advantages that

[18] H. A. Nelson and G. W. Rundle, Stress-Strain Measurements on Films of Drying Oils, Paints and Varnishes. Proc. A. S. T. M., Vol. 21, 1921, and Vol. 23, Part II, 1923.

are obtained by galvanizing. We have nothing to offer to show that this may not be one point in favor of zinc dust, but the tough, plastic nature of the zinc dust paint film, just described, must also be recognized as an important factor contributing to the excellent protective and adhering qualities of the paint.

Briefly considering the possible reasons for this property of zinc dust paint films, there are two major things that can have determining effects on the distensibility of a paint film (in the absence of absorbed moisture

FIGURE IX

Photomicrographs illustrating the plastic properties of a zinc dust-zinc oxide paint film after exposure for one year on the south side of a building.

"*A*"—Showing typical cut in a plastic material.

"*B*"—Paint film molded back into place and cut practically healed. (The remaining marks were practically invisible to the naked eye.)

which, in itself, has a softening effect). One is the retardation or arresting of the continuous oxidizing reaction that normally takes place in the vehicle on long exposure. The other is the physical properties of the reaction products (soaps) formed in the film, which may be soft and in themselves serve as plasticizers just as plasticizers function in lacquer enamels. The reaction products between zinc and fatty acids are not known normally to possess such plastic properties, so it is more than probable that the action here is mostly confined to retarding the continuous oxidation of the oil. One reaction product of a metallic zinc and the free acids, formed in the course of the oxidation of the oil, is hydrogen, which will be in a very reactive state. It is, then, easily conceivable that this hydrogen serves as an anti-oxidant (*i.e.*, reacts with the oxygen in the

film) and thus retards the oxidation of the oil. The hydrogen formed is diffused through the film or used up in a reaction since no blistering takes place due to gas formation within the film. This theoretical phase of the subject is being investigated and will be reported on later.

In spite of the plastic nature of the film and its very slight chalking tendencies, a zinc dust paint dries to a firm film on the surface and sheds dirt very well. This is especially true if from 15% to 25% zinc oxide is added. There is no evidence of a tacky surface.

Hiding Power

Since it consists almost entirely of metallic zinc, zinc dust can not be appreciably transparent to ordinary visible light and, therefore, does not

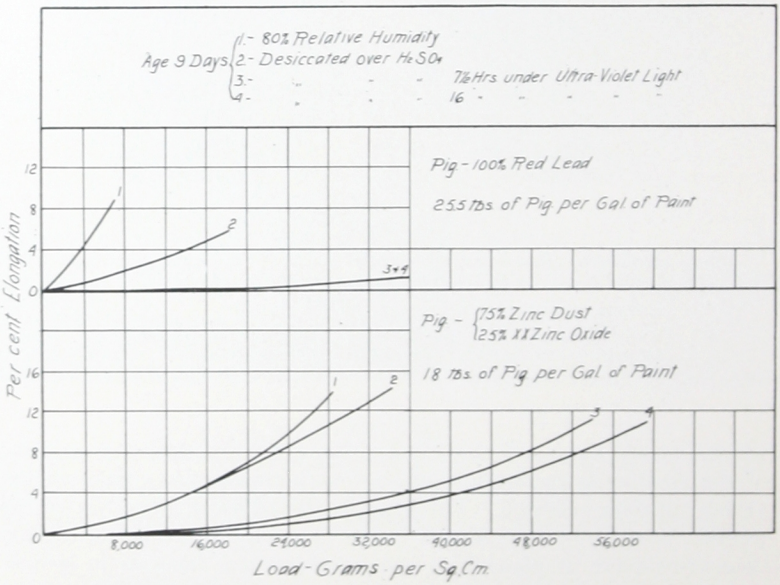

FIGURE X

Stress-Strain Measurements on films of 75% zinc dust–25% zinc oxide paint compared with 100% red lead under similar conditions. (Note greater toughness of zinc dust film, as well as slight effect of changes in humidity conditions and marked retention of distensible properties after exposure.)

depend on diffraction of light by a large number of microscopic particles for its hiding power, as do the transparent pigments. It follows, of course, that any film that provides a perfectly continuous layer of zinc dust one or more zinc dust particles in thickness should completely hide the surface beneath. Cryptometer hiding power measurements on an 80% zinc dust–20% zinc oxide paint, taken over a white background, give readings of approximately 1800 square feet per gallon. (Ordinary outside white paints over black background will hide about 225 square feet per gallon.) One ordinary coat of a properly thinned zinc dust paint, even when considerable amounts of zinc oxide have been added, can be depended on to obscure entirely a background of any color.

V

Present Recommendations for the Preparation and Use of Zinc Dust Paints

1. *Specifications for Zinc Dust*

We do not yet know the exact effect of variations in zinc dust on the quality of the paint films. The material that has been used throughout in exposure tests is a condensed zinc vapor, not atomized zinc. However, satisfactory paints have been prepared from atomized zinc dusts and there is no reason to doubt their efficacy in service.

Fineness is an important factor. Generally, the somewhat gritty surface obtained with a moderately coarse zinc dust is not objectionable in a priming paint, because the rough surface furnishes such excellent anchorage for subsequent coats. But extreme coarseness encourages settling and causes trouble in spray guns. Early experiments were conducted with a zinc dust which met a specification of 90% through a screen of 45 micron opening (No. 325 screen). The film obtained with this material was quite gritty for a finish surface, but not too much so for priming purposes. More recently a material meeting a specification of 95% through a 45 micron opening (No. 325 screen) has been used very successfully. This has about sufficient coarse material for priming paints without showing any objectionable grit when used in a finish coat paint and can be recommended for general paint purposes. The following is a typical specification for material that has given entire satisfaction for all purposes:

Fineness	95% through 45-micron opening (No. 325 screen) by dry screening method Maximum
Zinc Oxide	0—6.0
Pb	0—0.30
S	0—0.10
Fe	0—0.30

2. *Use of Zinc Oxide With Zinc Dust*

The chief functions of zinc oxide in zinc dust paints are to harden the film to any desired extent and to help keep the zinc dust in suspension. According to our present knowledge, the latter is probably of more immediate importance. However, if coarse material is avoided, zinc dust itself shows surprising little tendency to settle and does not cake. The addition of a small percentage of zinc oxide practically eliminates all tendency to settle. Cans of prepared paint with 25% zinc oxide have stood undisturbed for over two years without showing excessive settling or the slightest trace of caking at the bottom.

Any zinc dust paint with up to 25% zinc oxide exhibits a surprising amount of the "tooth" that is so well liked by painters in applying a paint with a brush.

Still another function of zinc oxide is, of course, to brighten the color, the addition of 20% yielding a very pleasing medium grey, which is almost an exact match for The New Jersey Zinc Company's standard "Palmerton Grey" for plant painting.

Experiments have indicated throughout that for metal priming the amount of zinc oxide used with zinc dust should not be over 25% and preferably 15 to 20% (by weight) of the total pigment.

3. *Percentage of Vehicle*

Our experiments have led to the conclusion that a defect in some of the zinc dust paints used in the experiments described in the literature is the addition of too much vehicle. The vehicle content should be regulated to yield a "good painting consistency" and excessive thinning avoided. With an ordinary boiled linseed oil vehicle this will vary from approximately an 85–15 pigment-vehicle ratio for 100% zinc dust to a 78–22 pigment-vehicle ratio for 75% zinc dust–25% "XX" zinc oxide (American Process Lead Free) as indicated under the discussion of typical formulas. (See page 23.) These figures will vary, depending on the zinc dust and vehicle used.

Volatile thinner is usually added to ordinary paints to improve brushing properties and to cut the gloss of undercoats. Although zinc dust paints possess exceptional brushing properties without the addition of volatile thinner, and the gritty nature of the film offers an excellent anchorage, we still feel that the introduction of a small percentage of volatile thinner to priming coats is desirable, but this should not exceed 20% (by weight) of the vehicle portion.

4. *Type of Vehicle to Use*

Experiments have indicated throughout that uniformly good exposure results can be expected from zinc dust paints made with boiled oils or raw linseed oil and drier. Variations in the vehicles have not been studied to any extent, although good results have also been obtained with certain treated oils of the semi-varnish type.

The putting up of ready mixed paints containing zinc dust is complicated by the slow reaction of the metallic zinc in the zinc dust with free acid in the vehicle to form hydrogen gas, which, if not released, may finally develop enough pressure to blow the cover off or open a seam. Hence, only pure linseed oil of low acidity (acid number below 4, preferably) can be used if the mix is to be sealed away in containers for a period of time. The experimental work on the conditions governing the use of different vehicles and dryers in making ready mixed zinc dust paints is not complete at this time. Apparently, the two most important precautions for retarding gas formation are (1) to use only pure untreated moisture free oils of low acid number (below 6) and (2) to allow time for the free acid to react, either with zinc oxide or the zinc dust, before the container is sealed. More detailed recommendations will be furnished as the experimental work progresses. There is, however, a very practical way for so minimizing this tendency to generate gas that the mix can be handled for shipping and storage, namely, to reduce the total oil content to the smallest amount that will yield a workable paste ready for thinning with linseed oil and drier. The following is an example as a base for an 80% zinc dust–20% zinc oxide paint:

100 pounds "XX" Zinc Oxide (American Process) Paste (with 18% Oil)
328 pounds "Standard" Zinc Dust
13 pounds Raw Linseed Oil of low acidity.

The low total vehicle content of this paste (7%) offers a very negligible possibility of a reaction and especially so if low acid, moisture free oils are used in the first place. Such a paste set aside for three months had not developed any pressure in the can. Moreover, the paste has the further advantage that it is quite stiff and need not be sealed as tightly for transportation as would a more liquid paint. Neither pastes nor finished paints containing zinc dust will skin over readily and this adds to the ease of storing and handling them under working conditions, when containers are frequently left uncovered. For example, a paste made according to the above formula was set aside in an open quart can under a hot plate at a temperature about 45°C for eight days, and, at the end of this time, had shown absolutely no evidence of a surface skin.

No special attention need be given to the acidity of the vehicle used where the paint is prepared on the job from zinc oxide paste and dry zinc dust or by thinning the zinc dust-zinc oxide paste. Although varnish vehicles may cause thickening, even quite highly acid varnishes may be added if the paint is applied within about 24 hours after being mixed.

5. *Drier to be Used*

Zinc dust paints are normally moderately slow drying. One made with straight boiled oil and thinner may be too slow drying for some purposes (requires about 30 hours to dry under moderate drying conditions), and then the addition of about 3% (by weight of the vehicle) of a standard lead-manganese oil drier is recommended. With raw linseed oil, the drier used should be 5% to 6% (by weight of vehicle), depending on drying conditions.

For the reasons just stated (see page 21) it is not practicable to use any ordinary drier, which may be quite reactive, in a ready mixed zinc dust paint that is to be stored in a sealed container.

6. *Preparation of the Paint*

Zinc dust pastes and paints should not be ground in a paint mill. Any properly manufactured zinc dust is easily and thoroughly wetted by all oil and lacquer vehicles and it is only necessary to stir the pigment into the vehicle by the most convenient means at hand. No particular precautions are necessary in adding zinc dust, for it will not "lump" as other metallic powders are likely to do. In preparing the pastes or paints weigh out the zinc oxide paste (not dry zinc oxide), thin gradually with part of the vehicle and stir in some zinc dust, adding oil and zinc dust alternately until the mix is completed. Care should be taken that the raw or boiled linseed oil which is used is pure and of high grade.

7. *Precautions in Handling Zinc Dust*

Dry zinc dust, in common with some other metal powders, is subject to combustion by oxidation if allowed to stand in contact with water. It should, therefore, be kept in a dry storage. Commercial shipments are made in sealed tin containers and substantial kegs that are moisture proof.

8. *Spray Application*

No special manipulations are required in applying zinc dust paints by the spray method. At the usual pressure for industrial painting (60 to 75 pounds per square inch) the paint may even be used as prepared for

brush application. At lower air pressures (45 to 55 lbs. per square inch) the paint must be thinned.

In general, the paints described below for brush application should be reduced with petroleum thinners (meeting U. S. Interdepartmental Specifications for volatile thinners) to a consistency that yields the best results with the particular apparatus at hand, and also avoids skin drying under normal conditions of mechanical application. However, the amount of thinner added should not exceed one and one-half pints per gallon.

Under normal conditions, when paint is to be applied by spraying, the number of coats to be applied should be in a ratio of two coats by spraying where three coats by brushed method are called for. For two-coat spray application, use the priming coat as specified for regular three-coat work. For the finish coat use the third coat paint specified for three-coat work, reduced to spraying consistency.

On repaint work, one coat uniformly applied by spraying is considered adequate after any bare spots have been properly primed with the specified priming paint. The finish coat shall be finish coat paint as specified for three-coat work, which is thinned for spraying, as mentioned above.

9. *Typical Recommended Formulas*

When the material must be sealed in closed containers for a more or less indefinite period of time, it is recommended that a zinc dust-zinc oxide-linseed oil paste be used according to the following specifications:

	(Per Cent by Weight) Maximum	Minimum
Pigment*	94	93
"Standard" Zinc Dust	81	79
"XX" Zinc Oxide	21	19
Vehicle	7	6
Raw Linseed Oil (A. N. below 4.0)	..	100

This paste weighs about 37.2 pounds per gallon.

From this paste, or an ordinary zinc-oxide-linseed paste, zinc dust paint can be prepared as follows:

PRIMER (For Metal Surfaces)

(*a*) From Zinc Dust–Zinc Oxide–Linseed Oil Paste

Zinc Dust–Zinc Oxide Paste	100 pounds
Raw or Boiled Linseed Oil	1¾ gallons
Thinners	½ gallon
Liquid Oil Drier	1½ pints
Yield about	5⅛ gallons

(*The pigment mixture should show, on analysis, not more than 26% zinc as ZnO and not less than 74% zinc as metallic zinc.)

(*b*) From Zinc Oxide–Linseed Oil Pastes

"XX" Zinc Oxide Paste	100 pounds
(With 18% Linseed Oil)	
Raw or Boiled Linseed Oil	8⅞ gallons
Thinners	2¼ gallons
Liquid Oil Drier	6½ pints
"Standard" Zinc Dust	328 pounds
Yield about	21⅞ gallons

Second Coat (Metal Surfaces)

(*a*) From Zinc Dust–Zinc Oxide–Linseed Oil Paste

Zinc Dust–Zinc Oxide Paste	100 pounds
Raw or Boiled Linseed Oil	1½ gallons
Thinners	5¼ pints
Liquid Oil Drier	1½ pints
Yield about	5 gallons

(*b*) From Zinc Oxide–Linseed Oil Paste

"XX" Zinc Oxide Paste	100 pounds
(With 18% Linseed Oil)	
Raw or Boiled Linseed Oil	7⅝ gallons
Thinners	2⅞ gallons
Liquid Oil Drier	6½ pints
"Standard" Zinc Dust	328 pounds
Yield about	21⅛ gallons

Third Coat (Metal Surfaces)

(*a*) From Zinc Dust–Zinc Oxide–Linseed Oil Paste

Zinc Dust–Zinc Oxide Paste	100 pounds
Raw or Boiled Linseed Oil	2¼ gallons
Thinners	1 pint
Liquid Oil Driers	1½ pints
Yield about	5¼ gallons

(*b*) From Zinc Oxide–Linseed Oil Paste

"XX" Zinc Oxide Paste	100 pounds
Raw or Boiled Linseed Oil	11½ gallons
Thinner	4 pints
Liquid Oil Drier	7 pints
"Standard" Zinc Dust	328 pounds
Yield about	22¾ gallons

10. *Cost of Finished Paint*

The following percentage-weight composition formula (finishing coat) can be used by those interested in calculating comparative cost data, based on current prices for the materials in question.

Zinc Dust–Zinc Oxide Paint	Composition Per Cent (By Weight)		Pounds of Paint, Per Gallon	
Pigment	78%	....	18	.....
Zinc Dust (Standard)	....	80%	..	14.4
"XX" Zinc Oxide	....	20%	..	3.6
Vehicle	22%	....	5	.....
Linseed Oil	....	92%	..	4.6
Turpentine	....	3%	..	.15
Drier	....	5%	..	.25
Total	100%		23	

11. *Recapitulation of Some Special Uses for Zinc Dust Paint*

For Priming Galvanized Metal and Sheet Zinc: Zinc dust paint has been found particularly useful on galvanized metal and sheet zinc where adherence depends on the retention by the oil in the film of its plastic and distensible properties.

On Galvanized Fence: The present method of erecting galvanized fence and railings is such that often the zinc coating is cut from the iron. For example, this invariably occurs where pipe joints have to be rethreaded. The zinc dust-zinc oxide-linseed oil paste, with about one pint of liquid oil drier added to each 100 pounds of paste, (add a little linseed oil also if the mix is too heavy), plastered on the abraded places insures thorough protection against corrosion and avoids the marked color contrasts that naturally result from the use of any other really high-grade rust-resisting paint.

For Priming Wood Surfaces: Zinc dust paint makes an excellent primer for woods, such as cypress, red wood, etc., on which it is difficult to obtain good adherence. In this case, use the priming paint formula specified above, but add one pint of linseed oil and about one pint of benzol or some coal-tar thinner to each gallon of priming paint. The zinc dust paint affords good anchorage for any finish paint applied over it.

On Canvas Roofs: Flat canvas roofs demand a paint that remains plastic. Zinc dust paint, with boiled linseed oil as the vehicle, has been found to be particularly suitable for such jobs.

On Screens: Zinc dust paint (use finish coat paint thinned slightly to prevent webbing) imparts a new galvanized appearance to screens and protects them from corrosion. One gallon will cover both sides of fifty ordinary house screens.

Hot Surfaces: The muffler of an automobile, for example, usually suffers from rust after several months' service. A coat of zinc dust paint has been found to prevent rust forming. The vehicle (ordinary linseed oil can be used) burns away, leaving a coating which preserves the metal.

12. *Use of Zinc Dust in Lacquer Vehicles*

Zinc dust is as easily wetted by lacquer vehicles as it is by oil vehicles and no special mixing is necessary in preparing lacquer enamels with zinc dust. To obtain an exceptionally smooth finish, the enamel should be allowed to age for several days before applying. It makes an excellent tinting material which can be stirred in dry into any finished lacquer enamel. With typical standard lacquer vehicles, no tendency to form gas in the containers has been observed. The addition of some zinc oxide is recommended to retard settling.

Zinc dust lacquers have been tested and can be recommended for metal, wood, stone and slate surfaces exposed both indoors and outdoors. A typical formula for a light grey finish enamel for exterior use is as follows:

	Per Cent By Weight
Zinc Dust	16.3%
Green Seal Zinc Oxide	3.4
½ Second R. S. Nitrocellulose (30% Alcohol)	16.9
Castor Oil	4.1
Dibutyl Phthalate	5.9
Damar	2.0
Ester Gum	3.0
Ethyl Acetate	17.0
Butyl Acetate	14.7
Amyl Acetate	9.9
Butyl Alcohol	1.8
Toluol	5.0
	100.0%

To accommodate various spraying conditions the above formula may be extended to include further reduction with solvents and diluents.

In order to obtain a satisfactory finish film a zinc dust of about 97% through 45 micron opening (No. 325 screen) is recommended, and coarse particles must be absent. For priming purposes, the fineness requirements are naturally much less rigid.

13. *Use of Zinc Dust as a Tinting Pigment*

As a tinting pigment, zinc dust can be stirred in dry in any desired amount into ordinary outside paints. It has been so used with apparent beneficial effects on the physical properties of the paint film. The resulting color is a clear blue grey, which can be readily modified by adding more or less dry zinc dust, or other tinting materials.

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